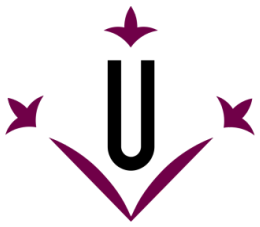

TControl: a Mobile App to Follow up Tobacco-Quitting Patients

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Abstract

Background: Tobacco smoking is a major risk factor for a wide range of respiratory and circulatory diseases in active and passive smokers. Well-designed campaigns are raising awareness to the problem and an increasing number of smokers seeks medical assistance to quit their habit. In this context, there is the need to develop mHealth Apps that assist and manage large smoke quitting programs in efficient and economic ways.

Objectives: Our main objective is to develop an efficient and free mHealth app that facilitates the management of, and assistance to, people who want to quit smoking. As secondary objectives, our research also aims at estimating the economic effect of deploying that App in the public health system.

Methods: Using JAVA and XML we develop and deploy a new free mHealth App for Android, called TControl (Tobacco-quitting Control). We deploy the App at the Tobacco Unit of the Santa Maria Hospital in Lleida and determine its stability by following the crashes of the App. We also use a survey to test usability of the app and differences in aptitude for using the App in a sample of 31 patients. Finally, we use mathematical models

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to estimate the economic effect of deploying TControl in the Catalan public health system.

Results: TControl keeps track of the smoke-quitting users, tracking their status, interpreting it, and offering advice and psychological support messages. The App also provides a bidirectional communication channel between patients and clinicians via mobile text messages. Additionally, registered patients have the option to interchange experiences with each other by chat. The App was found to be stable and to have high performances during startup and message sending. Our results suggest that age and gender have no statistically significant effect on patient aptitude for using TControl. Finally, we estimate that TControl could reduce costs for the Catalan public health system (CPHS) by up to €400M in 10 years.

Conclusions: TControl is a stable and well behaved App, typically operating near optimal performance. It can be used independent of age and gender, and its wide implementation could decrease costs for the public health system.

Keywords: smoke-free, mHealth, Healthcare, Mobile app

1. Background

Tobacco smoking is a major risk factor for active and passive smokers in certain respiratory [1] and circulatory diseases [2] as well as in some types of cancer[3, 4] and infections [5], among other diseases. Because of this, both public and private medical institutions in an increasing number of countries provide services for people who want stop smoking.

NRT (Nicotine Replacement Therapy), in the form of nicotine patches and/or nicotine gum, is effective at treating short-term nicotine withdrawal. Depending on the treatment and replacement, the chances of patients managing to quit smoking are increased by between 50% and 70% with NRT [6]. However, NRT alone becomes ineffective after about 8 weeks of starting the treatment and its effect in maintaining a smoke-free patient over a longer period of time (years) appears to be quite modest, as demonstrated by the meta-analysis of different studies [7, 8]. In light of this, some countries, such as the USA [9], the UK [10] and Australia [11], have published evidence-based guidelines to recommend effective tobacco cessation interventions ranging from brief instructions for quitting to extensive counseling combined with pharmaceutical adjuncts [12].

Patient-doctor contact and follow-up are very important psychological aspects of the process of quitting smoking, because they provide support and help maintain patient reinforcement [13, 14, 15]. For example, a recent study [16] confirmed that proactive telephone counseling is effective in the short-term reduction of cigarette consumption and in increasing the percentage of smokers who attempt to quit by more than 5%, when compared to people without phone counseling. In addition, it was found that text messaging can double the likelihood of smoking cessation for patients that have neither continuous contact with their caregivers nor personalized follow-up [17]. This is consistent with the finding that smoking cessation interventions via mobile phone-based text messaging have a positive effect on long-term patient outcomes [18]. For example, S-PC [15, 19] is a web-based e-medicine service that manages a central database of information on patient progress in a smoke quiting program being run at the public hospital Santa Maria in Lleida, Spain. Originally, S-PC uses mobile text messaging to follow up and manage patient progress. It evolved and became integrated in SHUITE (Simple Health Universal and Integral Treatment Environment), a non-free "Software as a Service" cloud framework responsible for managing patient and clinical information.

Thus, depending on the penetration of mobile phone usage, having Apps that automatically manage smoke quitting patients and their patient-doctor communication might be a very effective way to improve smoke quitting treatment outcomes. That penetration appears to be high. For example, 90% of U.S. adults use a mobile phone. 64% of those adults have smartphones that are also used as their primary source of Internet connectivity [20]. Furthermore, 62% percent of smartphone users use that phone to look up information about a health condition [21]. Spain has the second highest smartphone penetration in the world, and 88% of the Spanish population owned a smartphone in 2015, up 3% from 2014 and 19% from 2013 [22]. In addition, 70% of Spanish smartphone users connected to Internet daily through this device. More than half of these users navigate for more than thirty minutes.

There are documented benefits for smoke quiting patients of keeping patient-doctor contact through text messaging and there is a high penetration of smartphones [17]. Hence, developing Apps for automating the contact and follow-up between patient and doctor during the process of quitting smoking could have significant impacts in smoke quiting programs in the Spanish health systems.

Taking all this into account we set out to evolve S-PC into a smartphone

mobile health (mHealth) App that is efficient and free. In this study we report the development and limited evaluation of this App, which we now call TControl. TControl was developed to (a) be generally applicable in smoking cessation treatment programs, (b) automate much of the work that needs to be done by the clinicians, (c) allow professionals to maintain an efficient and personalized support and follow-up of patients, (d) give patients the psychological support required to stop smoking successfully, and (e) decrease the time clinicians need for managing the patients and reduce the average length of waiting lists. TControl can be freely downloaded from Google Play or the Android App Store. We study T-Control stability, usability, aptitude and performance. We also use mathematical modeling to estimate the economic effect that deployment of TControl might have at the level of the Catalan public health system.

2. Methods

2.1. TControl

TControl is designed to revamp, update and extensively expand the current system of communication with the SHUITE server, offering an App that was not previously available for smartphones.

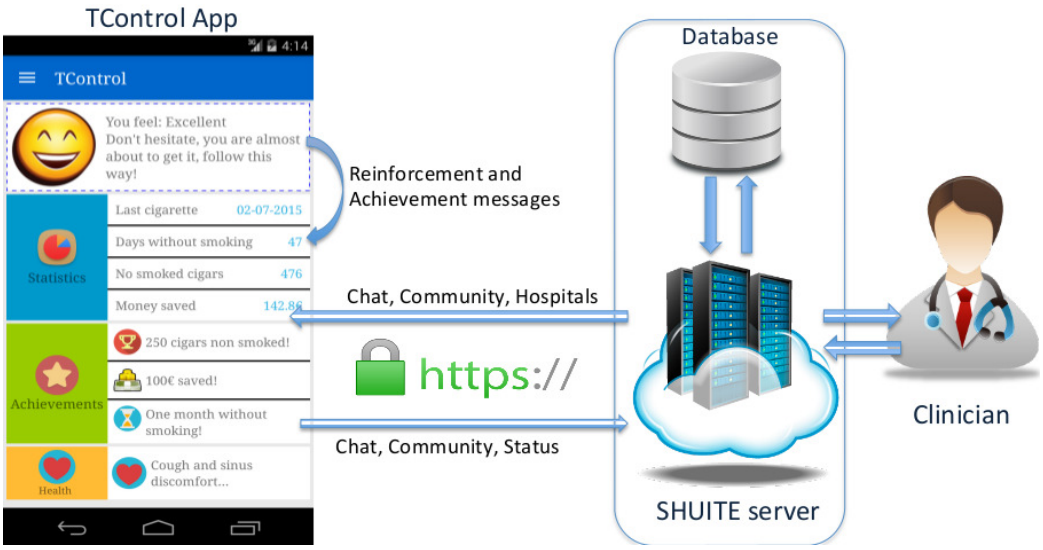


Figure 1: TControl operation.

Fig. 1 shows the overall operation of TControl. The SHUITE server is responsible for sending/receiving messages to/from TControl. All communication between the SHUITE server and the TControl App is encrypted using the HTTPS protocol. The server also provides the patient with a list of hospitals that use TControl for patient support in their smoke quiting programs.

Patients can use TControl to send weekly reports from a smartphone to the SHUITE server by filling a small form, via Internet. SHUITE receives these reports and stores them in an evergrowing database of clinical histories and message texts. The database is encrypted and hosted on a secured server.

SHUITE interprets the weekly reports to monitor patient status. Depending on that status, the clinician will be sent a warning to contact the patient, which s/he can do either using the chat tool of TControl or outside of the App.

TControl can also be used for semi automated self-monitoring and psychological support of patients, via achievements. The App also throws push reinforcement messages scheduled by the clinician to enhance the willpower of the patient. Achievement and reinforcement messages can be sent to a particular patient or to every member of a health plan group. TControl can also be used by the patients to chat with a clinician or a community of patients, managed by a clinician.

2.2. TControl Design

Currently, there are many alternative technologies for developing applications for mobile devices. The TControl was implemented using JAVA and XML, which are the native languages for the Android platform. Two important design requirements were that the application should be compatible with Android (the most popular mobile operating system) and guarantee optimal performance. Functional requirements were collected from the clinicians of the Tobacco Unit of the Santa Maria Hospital.

Usability criteria have been seriously taken into account when implementing TControl. As a consequence, users' access to any functionality is a single click away, using a unique menu button (located at the top left of the screen). That button appears or disappears at the user's will, making navigation simple and intuitive and improving the appearance of the App.

The possibility of allowing the App to push notifications to the application was ruled out in favor of querying the SHUITE server periodically and

using the Android inbuilt lns (local notification system) to display the interactive user messages. We optimized this process to minimize device-server communication and decrease use of Internet data by the device. The reason for choosing lns was that using a third party's software to implement a complete and efficient push notification service would require users to pay a fee, making it impossible for TControl to be a free App.

Ad-hoc webservices are used to establish communication with SHUITE using a secure HTTPS[2] protocol and exchanging data in JSON[3] format. The implementation ensures low data capacity requirements in the device and avoids legal problems with clinical data that remain securely stored only in the SHUITE server and never in the devices. This necessary security comes associated with the small cost of obtaining the required information remotely. This cost does not significantly affect the user experience.

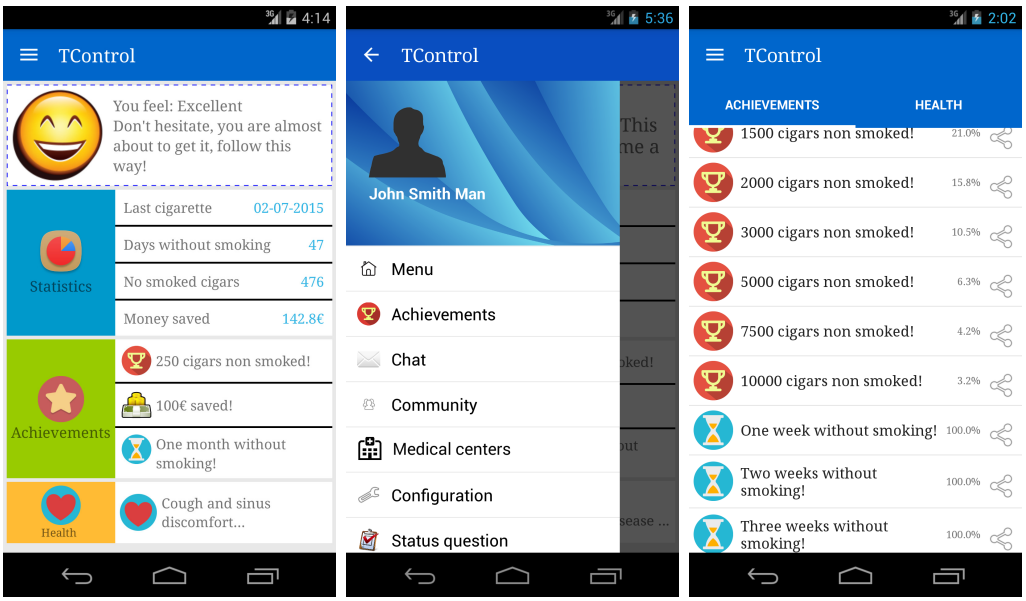
2.3. TControl Operation

Upon entering TControl for the first time, users fill a form to answer several questions: date that they stopped smoking, number of cigarettes s/he used to smoke, *per diem* expenditure on tobacco, etc. The answers are used to prepare the initial statistics and achievements for that patient. The user can only see the main window of the App after filling out this form (Fig. 2a). There is no need to be registered to access this window. However, users must be accepted by a hospital and be added to a treatment plan before statistic information and chats are enabled for their personal use. If patients are already registered in the SHUITE server, they can download all their private information to their phone from the server. This information includes any data in their profile, chats, community chats, hospital visits, clinical history or scheduled visits.

The main window is divided into four sections (Fig. 2a). The first section displays the latest feedback from the patient, which expresses his/her latest desire to smoke and a customized psychological reinforcement quote. The second section is composed of a set of statistics to inform how the patient is evolving. The app shows days without smoking, number of cigarettes not smoked, and amount of money saved by not smoking these cigarettes. The

[2]HTTPS. Communication over Hypertext Transfer Protocol (HTTP) within a connection encrypted by Transport Layer Security (TLS).

[3]JSON. JavaScript Object Notation. Open standard format that uses human-readable text to transmit data objects.



(a) Main window. (b) Feature Menu. (c) Achievements.

Figure 2: TControl main screens. (a) The main window: contains fast links to the app features, the latest achievements and an emoticon with the last sent status (excellent, good, regular or bad). (b) Feature Menu: links to features achievements, doctor and community chat, hospital geolocation, app configuration and sending status. (c) Achievements: saved time, money and cigarettes and health achievements.

third section contains the latest patient achievements. Finally, the fourth section informs the patients about the health improvements in their bodies.

TControl has the following functionality (see Fig. 2b): (a) registers the patient's compulsion to smoke and sends it to the SHUITE server, (b) permits chatting (instant messaging) between patients and clinicians (or medical team), (c) permits community chat (instant messaging) between patients, (d) sends personalized psychological reinforcement messages and phone notifications to avoid patients relapsing, (e) sends achievement messages (see Fig. 2c) to motivate the patient with money saved, cigarettes not smoked and time without smoking, and (f) provides information about hospitals, such as hospital contact details, location, etc.

These main functionalities are explained separately below.

2.3.1. Registering compulsion to smoke

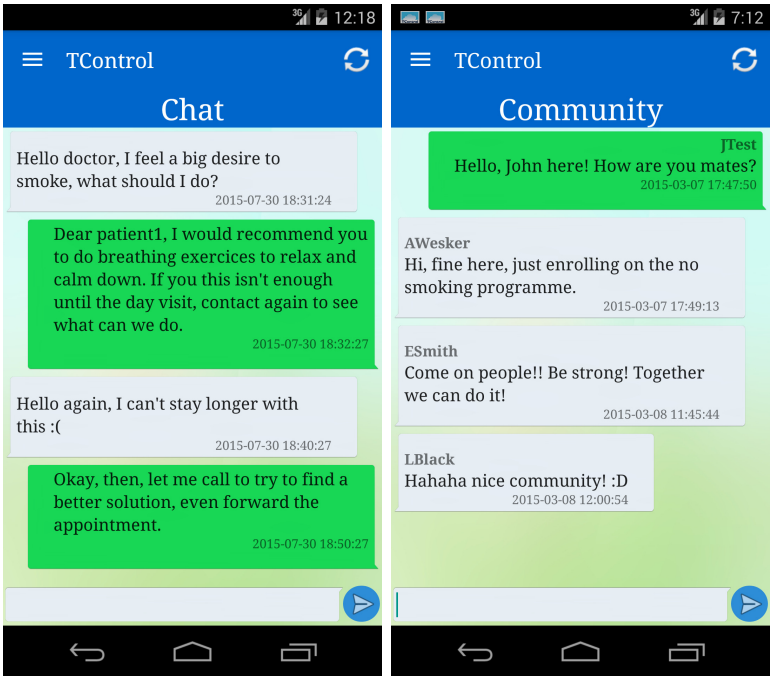
The patient chooses between one (low compulsion) and four stars (high compulsion) and TControl sends the choice to the SHUITE server. Next, the App immediately shows one of four possible emoticons, indicating the status of the patient. In addition, a short message provides psychological support and advice to the user. This support is personalized and depends on the status of the patient.

There are four possible states (emoticons) and eight associated messages (two per state, scheduled in a round-robin way):

1. Excellent (very happy).
   (a) Keep doing it! This is the way to become a non-smoking machine! Don't stop now!
   (b) Don't hesitate now, you are almost about to achieve your goal, keep going!
2. Good (happy)
   (a) Keep on with the struggle! Together we'll get out of this!
   (b) People might say you can't do this, but you can! You're quitting it, it's real, don't step back now!
3. Regular (regular).
   (a) Alright, it's fine, you can think about it, just don't do it. Stand up, be strong and keep on going, you will get out of this.
   (b) Replacing the cigarette on your mind with a smile on your face today will replace illness with health and happiness in your life tomorrow. Keep on going, don't loose your bearings.
4. Bad (sad).
   (a) Don't think about it, don't bother doing it. Tobacco doesn't suit you!
   (b) Don't smoke - there are cooler ways to die.

2.3.2. Chat-Community

TControl allows patients to contact the medical team. Whenever required, a patient can easily ask the doctor a question through the chat facility (Fig. 3a). The doctor's response will appear on the same screen. TControl allows the doctor to assign the patient to a user community with a similar treatment plan. Patients assigned to the same community can speak to each other and share their experiences, doubts and everything related to the



(a) Chat messages (b) Community messages

Figure 3: Communication.

treatment (Fig. 3b). This is very useful because patients usually feel more confident and supported when talking to each other, instead of asking or revealing personal feelings to their doctor.

2.3.3. Hospitals

The SHUITE server has a list of associated hospitals that have a Tobacco Unit and are TControl partners. Users can be registered in any hospital on the list. However, TControl assumes that users will want to be treated in the nearest hospital and sorts the list by distance. When selecting a hospital, the information displayed consists of a map (like *Google Maps*) which indicates your position using the Google Location Service, and shows the path from your location to the hospital. It also shows the address of the hospital and its head doctor's work e-mail. Patients are able to contact the tobacco specialist via email or visit in situ. This enables patients to easily and securly contact the nearest tobacco unit in an hospital offering the service.

2.3.4. Reinforcement Messages

Each TControl patient has several psychological reinforcement messages assigned to him/her. These messages are personalized and managed by the clinician in charge. The frequency and number of reinforcement messages to be sent to each patient are also fully customizable. These messages are sent to the patient to encourage the patient to continue the treatment in the anti-smoking program. For example, a patient could receive a daily notification message in their smartphone to improve their mood.

Table 1 shows a sample of positive psicological reinforcement messages that have already been used by the Santa Maria Hospital in Lleida.

Positive Reinforcement Message
Welcome to the Support Program to quit smoking. You will receive a series of support and encouragement messages.
Not smoking is not as hard as it seems, cheer up!
Come on, you can quit smoking!!
Do you breathe better? Are you less tired?
You surely are a good example for a lot of people!
Appreciate the advantages of not smoking. Congratulations!
Less tobacco equals to more self control!

Table 1: Sample positive reinforcement messages designed by a specialized clinician at the Santa Maria Hospital in Lleida.

2.4. Analysis

2.4.1. Stability

Crashlytics was used to analyze the failures and stability of TControl, done with 5 test users over a period of six months. Crashlytics enables real-time control of the users who are active, sending customer betas and collecting exhaustive information about crashes as they occur. This permits a rigorous control of application failures and crashes.

2.4.2. Usability and aptitude of potential patients

To measure the *usability* of TControl, we performed a short survey (see Table 2) to assess how patients perceive the app. The survey had 8 questions with a yes/no response format.

Aptitude is defined as the ability of patients to use the mobile application. This ability was also evaluated with a questionnaire. Three questions were asked, with two possible answers (yes/no):

1. Do you have a mobile phone for personal use and do you usually send and receive messages?
2. If you have a mobile for personal use, is it a Smartphone?
3. Do you have email or WhatsApp and do you check it daily?

By answering affirmatively to at least one of the three questions, the user was deemed apt for using TControl. The two questionnaires were answered by a sample of n = 31 patients between 01/11/2014 and 28/02/2015 at the Tobacco Unit office of the Hospital Santa Maria in Lleida.

2.4.3. Performance

We assessed the performance of TControl when executing its most critical operations: App startup and App access to Internet and communication with SHUITE. That assessment was done by measuring startup time and elapsed time when a request for information is sent to SHUITE. We tested two types of connections, Wifi (with 12 Mb/s download and 0.8 Mb/s upload speed) and 4G Data Internet. The entire Wifi bandwidth was solely dedicated to the TControl application during the experiments.

In addition, we also compared TControl with most of the main market apps that provide a similar service and have comparable features: Kwit, Smoke Free, Respina App, Quit Now Pro, ExFumador Pro and Stop Smoking.

2.4.4. Economic effect of TControl deployment on the CPHS

We analyzed the economic effect that deploying a TControl like application over the CPHS (Catalan Public Health System) might have. Direct savings are derived from a lower consumption of health resources by non-smokers compared with smokers [23]. In Spain, this differential consumption has been estimated at about €700 per person per year [24] (Data from 2005). Other international studies have estimated this differential consumption at only about €200 [25] (Data from 2006). We use this value in our calculations. In addition, according to the most recent numbers made available by the Spanish National Tobacco-Prevention Commitee, the annual social and health cost of treating a person to stopping smoking is €433. In 2013, there were 2,001,717 smokers in Catalonia [26]. Assuming that all smokers are enrolled in a traditional smoke-quitting program, it is possible to obtain the cost of the treatment for the CPHS.

3. Results

3.1. Stability

Fig. 4 shows an example of debugging with Crashlytics. A total of 138 crashes occurred. 90% of them were due to simple programming errors, like null pointer exception, RAM memory allocation, differences between received and expected structure of data incoming from the server, exceptions due to conversions and operation with floating point numbers, database exceptions due to requesting data from non-existent registers or fields of the DB. The remaining 10% of the errors were caused by issues such as bad communications between the app and the server, Google GPS location services, etc. All these issues were successfully solved.

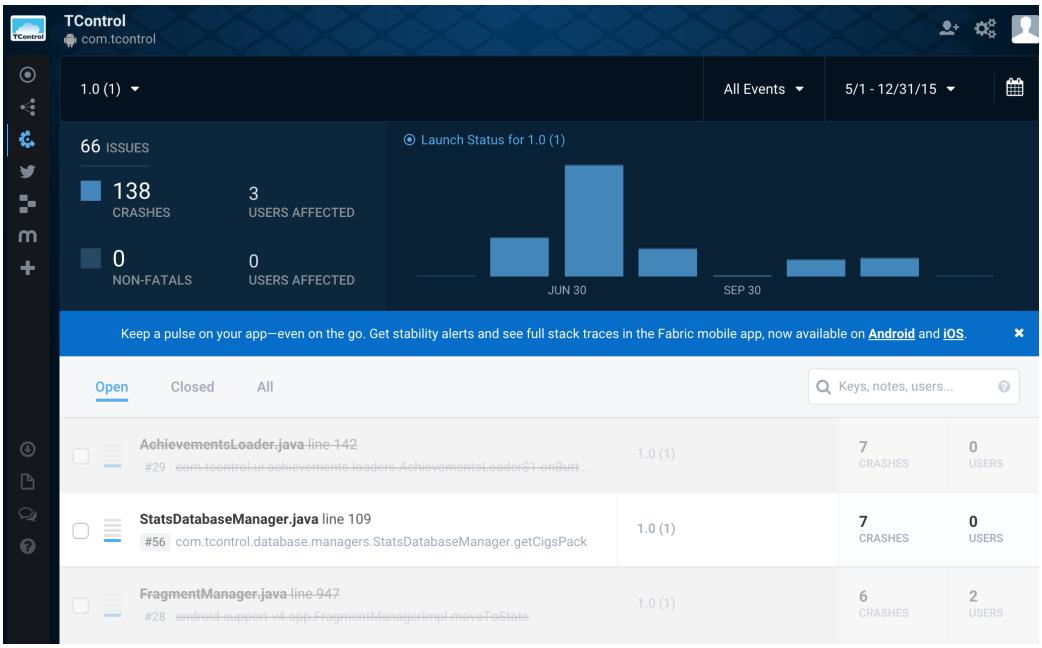


Figure 4: TControl in Crashlytics GUI.

3.2. Usability

Table 2 summarizes the results for the usability survey. Most patients have a positive attitude towards the App and they generally think that it has good usability standards. However, results show that 50% of the patients needed some kind of help to use the App at some point.

Question	Yes	No	NA
I think that the App is easy to use	31	0	0
The App is unnecessary complex	1	28	2
I have needed help to use the App	13	17	1
The App features are easily accessible	31	0	0
The App can have a great acceptance	30	0	1
The App is not intuitive	3	27	1
The App is easy to install and configure	20	9	2
The App is monotonous	2	28	1

Table 2: Usability survey done to 31 patients at the Santa Maria Hospital in Lleida.

3.3. Aptitude

We analysed the aptitude with respect to gender, age, type of mobile phone (smart vs. non smartphone) and means of communication (email vs. WhatsApp) (see Table 3). In terms of gender, age, or type of mobile phone, there is no statistically significant difference in the aptitude for using the application between the various groups of individuals. Using Fisher's exact test for a one tailed distribution, the p-value for gender differences is 0.67, that for difference between age groups is 0.32, and that for differences between types of mobile phones is 0.11.

Similarly, there is no statistically significant difference in aptitude between the group of users that are accustomed to using WhatsApp and those that use email.

This lack of significant statistical differences is also reflected in the Odds Ratios presented in Table 4, which are all very close to 1.

		% Suitable	% Unsuitable	Total individual
gender	**Male**	86.67	13.33	15
	Female	88.23	11.77	16
age	**< 50**	92.3	7.7	15
	50-65	81.25	18.75	16
mobile	**Smartphone**	87.09	12.91	24
	others	57.1	42.9	7
communication	**email**	75	25	4
	WhatsApp	88.8	11.12	27
Total		77.05	22.95	31

Table 3: Aptitude results. Percentage.

		Odds Ratio	Total individual
gender	**Male**	0.9244	15
	Female	1.0817	16
age	**< 50**	1.0524	14
	50-65	0.9502	17

Table 4: Aptitude results. Odds ratio.

3.4. Performance

The success of patient interaction with TControl mainly depends on two factors: application startup time and App-server transaction time.

The startup process includes two phases. First, the application starts up, showing an initial screen. While this screen is displayed, TControl typically downloads 1 MB of data from the SHUITE server. We measured how much these two phases took under both, 4G and Wifi connections. On Table 5 we present the average times for 30 replicate connection experiments. We note that startup times were on average 45.24% faster for the Wifi connection. This was expected, because the Wifi connection is much faster than 4G. However, even in the worst case scenario (4G), TControl behaved properly.

	Wifi (ms)	**4G (ms)**
Startup App	2,388.625	4,361.75
Send Chat Msg	357.875	1,488.75
Send community Msg Msg	175.125	385.125

Table 5: TControl performance.

The transaction time performances were obtained by measuring 30 replicate chat or community message deliveries to the SHUITE server (see Table 5). This operation ends when TControl updates its status. In this case, we can see that the Wifi connection is on average 73.95% faster than 4G connection.

Next, the performance delivering a community chat message was measured (see Table 5). As expected, the Wifi connection was 54.53% faster than the 4G one. These results are consistent with those obtained for startup comunication times between TControl and SHUITE.

We also note that we measured startup times for all the Apps compared in section 3.5 and found that TControl took either less or an equal amount

of time to startup operations.

3.5. TControl vs. Similar Apps

TControl has some important differences compared with other current apps (see Table 6). These differences include patient-monitoring, which provides the patient with the confidence of being monitored and assisted by a real doctor. TControl does not show the patient's evolution with charts, like Kwit, Smoke Free and Exfumador Pro do, but it does show the status of the patient's last week's desires to smoke. This was deemed as being more useful to assist patient followup and treatment decisions by the clinicians that helped design TControl.

TControl allows private chatting with a real doctor, as mentioned above. It also provides a means for connecting and chatting with patient groups in the same treatment plan. Every patient at each hospital can text chat other patients from the same hospital to exchange experiences and tips. Other applications also support group chat communities but these are self-organized and there is no clinical supervision. Again, enforcing communities that are defined by the doctors was a feature incorporated into TControl at the recommendation of the clinicians from the Hospital Santa Maria de Lleida.

Like Kwit, Smoke Free, Respira App, Quit Now Pro, ExFumador Pro and Stop smoking, TControl uses achievements and statistics to help the patients during their treatment. TControl achievements are mainly reminders of the goals and challenges met by the patient during the treatment. Most apps include these features. Psicological reinforcment of the patients' willpower is another important feature of TControl, because it is the only way to decrease the frequency of hospital visits by the patients. This saves a significant amount of time to the clinicians and increases the number of patients that they can simultaneously treat. We note that TControl is the only App that allows for personalized and costumizable psicological reinforcement messages, managed by a real doctor. Kwit, Respira App and Exfumador Pro only have a group of pre-established messages (which cannot be changed or customized) inside the application.

3.6. Economic effect of a smoke quiting program on the CPHS

We estimated how much total money could be saved by the CPHS over 30 years on smoker patients if those patients stopped smoking. The calculations were done in the following way. First, we use the official number of smokers (O) reported for Catalonia in 2013 (2,001,717). Second, we assume that

Program	CM	Charts	DC	GC	Ach.	Rei.
Kwit	No	Yes	No	No	Yes	Yes
Smoke Free	No	Yes	No	No	Yes	No
Respira App	No	No	No	No	Yes	Yes
Quit Now Pro	No	No	No	Yes	Yes	No
ExFumador Pro	No	Yes	No	Yes	Yes	Yes
Stop Smoking	No	No	No	No	Yes	No
TControl	**Yes**	**No**	**Yes**	**Yes**	**Yes**	**Yes**

Table 6: Comparison between TControl and other similar apps. CM: Clinician Monitoring (clinical staff are in charge of supervising the patients. Chart: graphical evolution Charts. DC: Doctor Chat (direct chatting with the specialist). GC: Group Chat (chatting with a group of related patients). Ach.: phycological Achievement messages. Rei.: phycological Reinforcement messages.

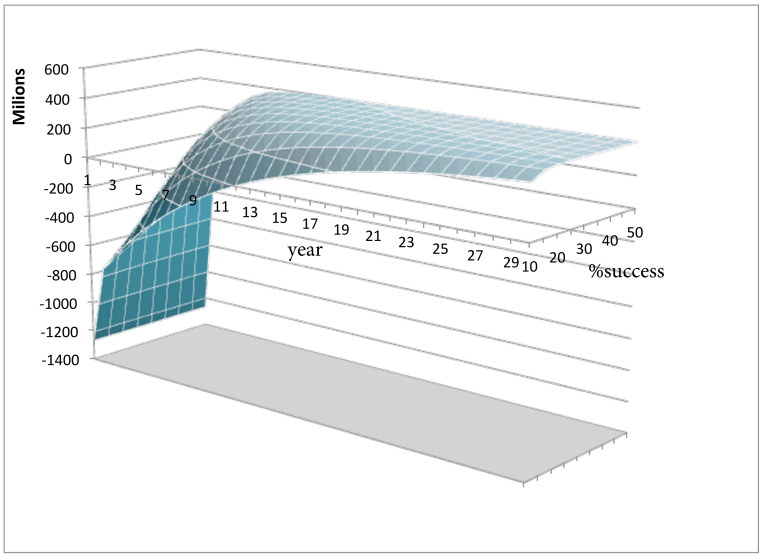


Figure 5: CPHS Savings.

the cost for the CPHS of enrolling each smoking patient on an anti-smoking program is €433 (2006 prices). Finally, we assume that the yearly cost (C) of a smoker patient for the CPHS is on average €200 (2006 prices). The savings created by smoke quiting programs are then calculated by assuming we enrol all smokers in 2013 and testing a varying degree of success for the smoke quiting programs (10, 15, 20 ... 50% success rate).

Figure 5 shows the economic estimations. This is, the savings (in €), depending on the elapsed time (in years) and success rate ($Savings_{year,\%success}$). The $Savings_{year,\%success}$ calculation at each time point is given by equation 1.

$$Savings_{year,\%success} = \begin{cases} -N_{year,\%success}[E+C], & \text{if } year = 1 \\ N_{year-1,\%success}C - N_{year,\%success}[E+C], & \text{otherwise} \end{cases} \quad (1)$$

where $N_{year,\%success}$ (equation 2) is the number of smokers for a given *year* and a success percentage ($\%success$).

$$N_{year,\%success} = \begin{cases} O, & \text{if } year = 1 \\ N_{year-1,\%success}[1 - \%success], & \text{otherwise} \end{cases} \quad (2)$$

Negative *Savings* values indicate that the CPHS would have to spend more money, while positive values indicate that the CPHS would save money. The results show that the CPHS would have to invest a significant amount of money during the first five years (depending on the success rate of the smoking quiting program). After this initial investment, the system would start to save money in 2 to ten years. At thirty years, the sum of money saved by the system per year on smoker patients (roughly €4 500 million) would be more than recoup the initial investment (€1 300 million in the best case scenario and roughly €2 800 in the worst case scenario). We note that the success rate of the smoke quiting programs only influences the results in the first five years. Thus, we predict that introducing these programs would contribute to the sustainability of the CPHS in the medium to long term.

4. Discussion

eHealth interventions to assist in substance abuse programs are becoming widespread and were recently reviewed by Das and colleagues [27]. They present and discuss Internet websites and web-based interventions, smartphone Apps and/or SMS services, social media tools, and video gaming. These applications are evolving and being developed at a pace that is much faster than that of well-controlled studies to determine their effectiveness in smoke quitting treatments. Nevertheless, pilot studies suggest a positive effect of web-based and app-based smoke quitting interventions on short term success [27, 28, 29, 30, 31, 32]. This is consistent with results from an early Cochrane review [18, 33] that found that use of Apps had a positive effect in

short term self-reported quitting, although it emphasized the need for rigorous studies to determine long term effects of these Apps in smoke quitting. Lack of studies to determine long term effects is still a concern.

The tool we present here, TControl, is a smartphone App developed to manage and follow patients in smoke quitting programs. It also includes primitive social network capabilities. Willingness to use Apps for smoke quitting attempts is widespread, although the effectiveness of making these attempts without medical assistance is questionable [3]. Nevertheless, a pilot trial indicated that reduced utilization of smoke quitting Apps could be linked to lower education, higher tobacco consumptions and depression. TControl was tested and debugged with 5 clinicians over a period of six months to become a stable and well behaved App that performs with no errors, as suggested by the results presented in section 3.1.

Two questionnaires (usability and aptitude) were answered by a sample of n = 31 patients. Usability tests suggest that TControl has successfully addressed common usability issues. However, 50% of the patients needed help to use the App at some point. Although this fact seems not to have affected negatively on the general opinion of the App, we plan to create a short online tutorial and create help items in TControl to assist in these situations. The results of the aptitude questionnaire pointed that TControl has great potential for use by men and women of any age. In addition, we will further pass the design of TControl through the filter of MARS (Mobile App Rating Scale), which is a tool for assessing the quality of health mobile Apps [34].

The time performance of the App is also good. The worst case scenario we tested measured a 4.36 seconds startup time, using a 4G connection. This number is bound to change, depending on the mobile phone and connectivity, but we expect that startup times will always be below 5 seconds in modern smartphones. Message sending under the worst case scenario was always below 1.5 seconds, suggesting again that the app performs very effectively. We note that connection speed, rather than terminal power was always the limiting factor in the time performance tests we made.

Simulation predicted that TControl could reduce costs for the Catalan public health system significantly (up to €400M in 10 years in the most optimistic situation), and by extension, for any public or private health service.

Finally, we note that the fast development of AI methods hold strong promise to further automate eHealth interventions such as those made possible by TControl. This is a route for development that we will also explore, in

light of recent case studies that were reported for fully automated program simulations of smoke quitting processes [35].

5. Conclusions

This article presents TControl, a mobile App to follow up patients trying to stop smoking. It was designed and successfully implemented in the context of an anti-smoking treatment in a public hospital in Catalunya, Spain. TControl can be successfully deployed in medical centers to keep track of smoke-quitting patients.

We note that TControl provides the patient with the confidence of being monitored and helped by a live doctor. This is the most important difference with similar Apps.

This App project is still not finished. In the future, a new release for iPhone devices will be launched. Furthermore, we will add new features, such as lists of medicines for the patients and new advice about sleeping and eating habits and physical exercise, managed by specialists. Finally, we plan to test the efficiency of TControl in a clinical essay with a larger cohort of patients at the Santa Maria Hospital in Lleida.

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